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ABSTRACT

This study was conducted to evaluate the usefulness of discriminant analysis in classifying vocational and technical curricular groups in a single secondary school setting. The researchers compared scores on the Dailey Vocational Test and the Minnesota Vocational Interest Inventory in terms of the selection of vocational and technical courses by 585 Grade 11 and 12 students in Kansas City, Missouri. After finding a statistically significant difference between vocational groups, the study concluded that discriminant analysis can be valuable in classifying students with aptitude and interest variables. (BH)

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INDIVIDUALIZED VOCATIONAL GUIDANCE: A NEW LOOK

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The Curators of the University of Missouri
for the University of Missouri - Kansas City

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Purpose

This study was conducted to determine the appropriateness of the use of the discriminant function statistic as a technique to aid in the classification of vocational and technical curricular groups in a single secondary school setting. By procedures of the discriminant function statistic, study was made of the relationship between scores on the Dailey Vocational Test and the Minnesota Vocational Interest Inventory on the selection of vocational and technical courses by eleventh and twelfth grade Kansas City, Missouri vocational and technical education students.

Method

A total of 585 students in sixteen vocational-technical courses were selected for study. Nine differential aptitude scores on the Dailey Vocational Test and 30 interest scale scores on the Minnesota Vocational Interest Inventory also were selected for study. The obtained test data for the 16 vocational groups on 39 variables were then processed in two phases (construction and validation), by a computer using appropriate discriminant function routines in an attempt to answer the following general question: Is the discriminant function statistic an appropriate technique to aid in the classification of vocational and technical education students in a single school district?

Results

The results of the discriminant analysis answering the proposed questions were:

1. A significant Wilks' criterion was obtained indicating that the centroids of the sixteen vocational groups were statistically different.
2. Three of the fifteen potential discriminant equations exhaust 74.7 per cent of the discriminating power of the 39 variables under study.
3. By using the maximum likelihood principle of classification 48.9 per cent of the validation sample

could be correctly identified with their actual vocational group. A greater degree of accuracy of prediction of group membership (70.7 per cent and 82.7 per cent) was possible by using the two or three largest probability values of each subject.

Conclusions

The following conclusion seems warranted in view of the findings.

Discriminant equations can be generated which will be of significant aid in classification of a single school system's vocational and technical students according to group resemblance by using aptitude and interest variables.

INTRODUCTION

Statement of the Problem

The purpose of this study was to determine the appropriateness of the use of the discriminant function statistic as a technique to aid in the classification of trade and industrial curricular groups in a single secondary school setting. Specifically, by means of the discriminant function statistic, study was made of the relationship between selected scores on the Dailey Vocational Tests, DVT, (1965) and the Minnesota Vocational Interest Inventory, MVII, (1965) and selection of courses by eleventh and twelfth grade boys and girls enrolled in vocational and technical programs in a single high school. In doing so the study will consider groups of students and variables not previously researched using this methodology, with the exception of the author's earlier pilot study, (Doerr, 1967).

This research study is a second step in an overall research design which has as its goal the combining of discriminant analysis and multiple regression statistical procedures into a paradigm for vocational guidance with the vocationally oriented secondary student. The first step of this research completed earlier, determined that vocational education students were in fact different with respect to aptitude and interests and that the single vocational course groups tended to have identifiable characteristics. Since this early study did not consider females nor was the population limited to a single school it was felt that these two conditions should be subjected to study to determine whether or not the characteristics earlier noted can be delineated within the female course offerings in a single environmental setting.

Need for the Study

The United States Government has, in the last decade, increased its emphasis on and participation in programs of vocational and technical education. This increased attention was in part initiated by the problems of continuing unemployment and its implicated cause, the school dropout. The magnitude of federal participation is apparent by the enactment of the National Defense

Education Act of 1958, The Area Redevelopment Act of 1962, The Manpower Development and Training Act of 1962, and the Vocational Education Act of 1963. The impact of this legislation on vocational programs in Missouri high schools is evidenced by the 188 per cent increase in program funding during the years 1963-66 (Swanson, 1966). Counseling and guidance of students enrolled in these programs is considered a major ancillary service because federal funds are provided for the establishment and support of guidance programs and personnel.

Contacts with school counselors are important to students in secondary school vocational-technical programs because the selection of a pattern of courses in high school has occupational implications. Job opportunities are restricted for many youth as a result of their secondary school experiences. This is particularly true of students who are enrolled in vocational education courses and spend one-half the time during their final two years of high school preparing for a specific trade or technical occupation. Decisions young men make while in high school will have an impact on their lives for many years.

Students selecting subjects in trade or industrial education curricula are, in essence, making vocational choices. To aid these students, counselors should have data which would indicate the degree to which aptitudes and interests of beginning students compare with individuals who have completed a given trade or industrial curricula as well as with persons who have successfully pursued related occupations for several years. The comparison of subject matter groups on these traits should include not only minimal acceptable levels of traits but also the extent to which such trait patterns vary from group to group.

The important role of aptitudes and interests in vocational choice has long been recognized by counselors as evidenced by the repeated appearance of research articles studying these variables. The rationale underlying the use of the discriminant function technique is that information on the ability and interest characteristics of potential vocational students in comparison to present vocational students would be valuable to individuals who are formulating their choices of vocational curricula. The problem is to classify students enrolling in vocational education on the basis of their aptitudes and interests as measured by objective tests. There are many preliminary steps to be taken in order to produce the information necessary to improve the selection and counseling of high school students desiring

to obtain vocational and technical education. Initially, it must be determined whether a group such as trade and industrial education students, who are generally considered to be homogeneous, can be differentiated by aptitude and interest measures. A successful methodological study to investigate this problem could pave the way for additional research to determine the extent to which beginning high school students resemble students who have completed required training programs as well as the degree to which they resemble persons who have completed a number of successful years in a given occupation.

Related Research

Discriminant Function

Multiple regression and multiple and simple correlation techniques are the usual statistical techniques used to predict academic success. While these techniques are helpful, they provide, at best, incomplete data for guidance purposes. In counseling with students it is not only useful to know their probability of success, but it is also helpful to know which groups they most nearly resemble. Such a task is a classification problem and refers to the prediction of membership in one of several groups rather than to the degree of success which may be attained. The major distinction here is that the criterion is categorical rather than continuous and calls for the use of multiple discriminant analysis techniques developed by Fisher (1936). Fisher originally developed the statistic in order to classify human skulls into four racial groups by means of studying specific skull characteristics. Briefly, his solution entails the maximization of the ratio of the among-group variation to the within-group variation. The maximization process produces a linear function of the characteristics under observation that will display differences between groups better than any other linear combination of these same variables. Excellent and complete reviews of the development and diverse applications of this statistic have been authored by Tatsuoka and Tiedeman (1954), Norton (1953), and Cramer and Bock (1966).

Use of the Discriminant Function

Among the earliest applications of multiple discriminant analysis to curricular groups was a study by Tiedeman and Bryan (1954). Using interest variables only, they reported that there were two important

discriminants among five curricular concentration groups of Harvard undergraduates. Dunn (1955), studying fourteen curricular groups at Brown University, reported that by means of discriminant analysis it was possible to correctly predict 50 per cent of the choices of concentration as contrasted with only 21 per cent accuracy by means of regression analysis. Whitla (1957) investigated entrance examination scores at the University of Nebraska and reported significant discriminants among both colleges and major areas of study. More recently the technique has been used to study such diverse problems in education as personality profiles of college football teams (Kroll and Peterson, (1965), need patterns and abilities of college dropouts (Chambers, Barger, and Lieberman, (1965), predictions of dropouts within a school of agriculture (Stone, (1965), and a study of rehabilitation counseling outcomes (DeMann, (1963). Despite the increased and varied use of the discriminant function technique and the increased national attention given to school counseling and vocational education, there have been no studies reported since 1957 dealing specifically with the problem of curricular classification of secondary school trade and industrial students . The population of trade and industrial students has been subjected to discriminant analysis only at the post-high school level.

Research has been reported by Tiedeman, Bryan, and Rulon (1951) dealing with the classification of airmen for eight occupational specialties based upon data from the Airman Classification Battery, AC-1. The AC-1 yielded 17 aptitude variables for analysis. The results of the multiple discriminant analysis indicated that all of the information concerning the separation of the eight airman trade groups was described by two linear functions of the 17 variables. The two combinations were reported to represent mechanical and intellectual ability.

Ottman, Ferguson, and Kaufman (1956) used a modified approach to existing discriminant function techniques in studying 13 United States Navy occupational groups on both four and six aptitude variables. They chose to generate a Rao (1952) type classification equation for each of the 13 trade groups rather than to compute one or two Fisher (1936) type linear functions that would account for the separation of trade groups. Either method is appropriate and acceptable for dealing with the problem of group resemblance.

Tiedeman and Sternberg (1952) reported research dealing with the problem of broad curricular group

separation in a secondary school. They analyzed ninth grade Differential Aptitude Test Battery scores with respect to students' choices of curricula. The data were analyzed by the traditional correlational and multiple regression methods and comparison made with the relatively new discriminant function. The fallibility of the correlational and multiple regression techniques was graphically displayed and appropriately summarized. Three conditions of this study, however, made generalizations concerning the results difficult. First, the students in the study were in the tenth grade and, therefore, not as representative of a curricular group as a group of twelfth grade pupils who would be in the final stages of curricular preparation. Secondly, students in the school selected for the study chose other curricular groups in insufficient number to have all possible curricula analyzed. Third, only measures of aptitude were considered for analysis. The study is important, however, as it was the first attempt to measure the degree to which a student resembles a given curricular group in a secondary school.

Factors other than test variables were given consideration in a study reported by Cass and Tiedeman (1960) based upon Cass's (1955) doctoral dissertation. Age, sex, and family income were investigated along with scores from the following instruments: (1) Otis Quick-Scoring (Beta) Mental Ability Test, (Form CM), (2) Kuder Preference Record, Vocational (Form CM), (3) Bennett and Fry Mechanical Comprehension Test (Form AA), (4) Minnesota Clerical Test - Numbers and Names Tests, and (5) Minnesota Paper Form Board (Form AA). Eighteen variables were thus available for each pupil. The group of pupils studied included all students available in the state from the secondary schools which offered the six general curricula industrial arts and agriculture.

The authors summarized their findings by stating:

> "The sex variable dominates the first discriminant and clearly differentiates the two areas of vocational education for each sex. The second discriminant differentiates the college-oriented group from the family economic circumstance, and orientation to academic areas. The third discriminant differentiates the two vocational education areas chosen by young men. The young women in the home economics or commercial curricula are not well differentiated by those eighteen variables."

This study offered a clue concerning the possibility that pupils in the trade and industrial education curricular, even though considered rather homogeneous in most schools, might have discernible differences in selected abilities and interests. The two vocational areas researched in this study were industrial arts and vocational agriculture which leaves the population of trade and industrial pupils unresearched.

Littrell (1957) studied college prep, distributive education, trades and industry, commercial and general education groups in a manner similar to Cass (1955) but limited the variables to general intellect and aptitude. Several of the tests and subtests were found not to relate significantly to the prediction of curricular patterns. The author concluded that classifications by test variables were possible but that there may be better instruments available than those studied.

The research reviewed suggests that the discriminant function is a valuable statistic for diverse types of classification problems including those relating to test variables and curricular selection within the heterogeneous population of a secondary school. These reports offer encouragement to pursue the study of the classification of trade and industrial education pupils on selected variables of the Dailey Vocational Tests and the Minnesota Vocational Interest Inventory in vocational-technical high schools.

Definition of Terms

Discriminant function as used in this study refers to the statistical procedure that will identify the uniqueness of separate vocational-technical course groups with regard to aptitude and interest variables in the defined groups. Mathematically the procedure will determine the uniqueness of each of the groups on m variables in k-1 or m (the smaller of the two) dimensional space.

Vocational-technical course refers to a class offered by a vocational high school for regularly enrolled secondary school students. The purpose of such a class is to provide for the acquisition of appropriate skills necessary to enter a related occupation upon completion of the course. The course meets for three class periods each day usually for two years. In this study Data Processing is an exception in that it is a one-year course enrolling only seniors.

Aptitude refers to measured performance of students on the Technical and Scholastic Test and Spatial Visualization Test of the Dailey Vocational Tests.

Interests as used in this study refer to the scores obtained by the subjects on the scales of the Minnesota Vocational Interest Inventory, MVII.

Limitations of the Study

This study was designed to investigate the applicability of the discriminant function as a statistical procedure to classify high school trade and industrial education students. Study was made of the relationship between vocational course selection by boys and girls and their aptitudes and interests as measured by the Dailey Vocational Tests and the Minnesota Vocational Interest Inventory. No attempt was made to account for other variables which may influence course selection.

Each participating school offered guidance and counseling for purposes of educational planning for all students. Additionally, the counselors pointed out that there were established selection criteria for many of the vocational courses. It is possible that test scores and past achievements not measured by the instruments of this study had an effect upon the students' placements. Test scores and achievement might have also depended upon the socio-economic position of each youth's family. It was felt that these were not serious limitations to the completion of this study.

Method

Subjects

The subjects comprising the final data for this study were 585 second semester junior and senior boys and girls in the Kansas City, Missouri public schools enrolled in 15 vocational and technical education courses during the 1968-69 school year. This final group size was arrived at by testing 802 students — 639 of whom completed all tests in the battery. Two follow-up test sessions were utilized to arrive at the 639 figure. It was felt that three attempts to gather a complete set of information for a student was all that was economically feasible due to the distance to travel and the desire not to disrupt the classroom routine more than had already occurred. Final identification of course groups to be included in the study was dependent upon enrollment in the course, a complete battery of scores for the student, and enrollment in the same course during the second semester. The latter condition was an attempt to control for inaccurate administrative placement of the student initially. No course group was included if after meeting the above conditions its size was smaller than 15.

Vocational Courses

The following is a listing of the vocational and technical courses with large enough sample size to warrant inclusion in the study.

1. Auto Mechanics
2. Auto Body and Fender Repair
3. Clerical Practice
4. C. O. E. Business Education
5. Commercial Art
6. Commercial Serving
7. Cosmetology
8. Data Processing
9. Electricity
10. Electronics
11. Graphic Arts
12. Key Punch and Machine Operation
13. Machine Technology
14. Refrigeration-Air Conditioning-Heating

15. Secretarial Practice
16. Stenography

Variables

The following variables were selected for the study on the basis that they were scores generated from tests that are considered to be appropriate for use with a secondary school vocational-technical population. They are:

Dailey Vocational Tests

1. Electricity
2. Electronics
3. Mechanical Information
4. Physical Science
5. Arithmetic Reasoning
6. Elementary Algebra
7. Vocabulary
8. Spatial Visualization
9. Business English

Minnesota Vocational Interest Inventory

10. Baker
11. Food Service Manager
12. Milk Wagon Driver
13. Retail Sales Clerk
14. Stock Clerk
15. Printer
16. Tab. Machine Operator
17. Warehouseman
18. Hospital Attendant
19. Pressman
20. Carpenter
21. Painter
22. Plasterer
23. Truck Driver
24. Truck Mechanic
25. Industrial Educ. Teacher
26. Sheet Metal Worker
27. Plumber
28. Machinist
29. Electrician
30. Radio-TV Repairman
31. Mechanical
32. Health Service
33. Office Work
34. Electronics
35. Food Service

36. Carpentry
37. Sales-Office
38. "Clean Hands"
39. Outdoors

Method of Analysis

The design of this study required that the data be processed in two separate phases. Computation of discriminant functions for the vocational groups on 39 variables was completed as Phase I. Phase II, a validation study, was accomplished by substituting in the discriminant equations generated, the test scores of each individual of the validation sample in order to determine the vocational group the individual most resembled. The computations involved in Phase I and II were completed by means of an IBM 360 computer at the University of Missouri Computer Research Center.

Phase I

The purpose of Phase I of this analysis was to determine whether or not vocational education curricular groups can in fact be differentiated by a set of aptitude and interest variables. The statistic chosen for the analysis was the discriminant function statistic of the multivariate analysis procedure described in Cooley and Lohnes (1962). Prior to calculating the discriminant equations it was necessary to test the discriminating power of the data by application of Wilks' lambda (Λ) test (Rao, 1952). Assuming equal dispersions (variance-covariance matrices) Wilks' Λ tests the significance of the null hypothesis of equality of population centroids (mean vectors). A significant Λ indicates that at least two of the groups differ and that the discriminant study should be continued.

In brief, analysis by means of the multiple discriminant function requires data consisting of the results on several variables by a number of groups. Let m represent the number of variables and k represent the number of distinct groups. A is an mxm matrix of among-group sums of products with each entry of the matrix computed similarly to the among-group sums of squares of analysis of variance. W is also an mxm matrix comprised of the within-groups sums of squares.

The problem is to find a set of coordinate axes which maximizes the differences between criterion groups. The number of axes that are necessary to explain the

total among-means variance will be k, the number of groups, minus one. The maximization procedure involves the simultaneous solution of equations, a process that is most efficiently completed by means of matrix algebra by electronic computers.

The above defined matrices are then a part of the basic matrix equation, $(A-W)v=0$ which is solved using matrix algebra, for λ , a scalar, (also called an eigenvalue) and for v, an eigenvector. The values obtained for λ 's comprised the major results of the analysis.

The rank order of the matrix A (the smaller of k-1 and m) will determine the exact number of non-zero solutions possible for the basic matrix equation. Each solution will produce one λ and m v's. The largest is then defined as the first linear discriminant function, the next largest is labeled as the second discriminant function, and so on until the smallest of k-1 or m is reached. The first discriminant function is the linear equation that best combines the m variables so as to maximize the ratio of the among-group dispersion to the within-group dispersion. The second discriminant function maximizes the ratio of the A matrix to the W matrix for that portion of the A matrix that was not accounted for in the first discriminant, and so forth until such time as all the variation has been explained. Each of the resulting functions are orthogonal to each other. This is another way of saying that each function explains some portion of the among-groups dispersion that is not explained by any other function.

Phase II

It is felt that the probable effectiveness of the equations should be displayed by empirical validation. The usual method used to determine whether or not the developed equations are effective has been to use the original sample data as a validation sample. A classification summary table is then tabulated to indicate the number of observations of each group which would be correctly classified by use of the discriminant function. This phase of the present study will make use of a random 10 per cent validation sample drawn from each group prior to the computations of Phase I. Thus, validation subjects' scores would not contribute to the discriminant functions and will be considered a more demanding examination of the effects of the equations.

FINDINGS AND ANALYSIS

RESULTS

Analysis of Dispersion

The use of the discriminant function technique is based upon the assumption that the groups to be classified are significantly different on a set of measurable variables. The method available to determine these differences in multidimensional space is a procedure of multivariate analysis of variance by Wilks (Rao, 1952). Wilks' (Λ) criterion, analogous to univariate analysis of variance, is a simultaneous comparison of the dispersion matrices of the criterion groups.

Wilks' criterion was computed for the sixteen vocational course samples on the 39 variables of the study and was found to be highly significant. The resultant Λ was .0174 which when tested by Rao's (1952) method yielded an F of 3.502 for 741 and 9712.992 degrees of freedom. The probability of obtaining that large an F by chance is less than .001. Wilks' criterion indicates that there are significant differences between the centroids of the vocational study groups thus calling for a continuation of the discriminant study.

Discriminant Functions

The solution of the basic matrix equation $(A-W)v=0$, where A and W are among and within group variance-covariance matrices, results in a set of eigenvalues (λ's) each of which has a corresponding set of eigenvectors (v's). Each set of eigenvectors comprises a discriminant function, the individual eigenvectors (v's) being the numerical coefficients of the original test variables. In the case of the present study the v's represent the coefficients of the thirty-nine variables in the discriminant equations. The resulting equations are of a form which enable them to be of immediate use for classification problems.

The coefficients of the variables of three discriminant functions resulting from the solutions of the basic matrix equation are presented in Table 1.

Discriminant function I would actually be represented by the following equation:

$$Y_1 = .119X_1 - .070X_2 + .115X_3 + \ldots + .047X_{37} - .194X_{38} + .080X_{39}$$

Where Y_1 is the discriminant or classification score for an individual on discriminant function I and X_1, X_2, X_3,....X_{39} represent the test scores of an individual student on the variables.

The researcher employing the discriminant function statistic is faced with the decision of determining how many of the computed discriminant equations to use in subsequent analysis or in the interpretation of the group differences. Rao (1952) reports the availability of two approximate tests of significance as a method of selecting the number of usable functions. Cooley and Lohnes (1962) suggest a simpler and equally useful procedure for the selection of the fewest number of equations which account for the major share of discrimination of the groups. They point out the desirability of selecting the first few equations which would exhaust a maximum amount of the variance while at the same time minimizing the number of predictor dimensions.

Use of the latter procedure indicates that the least number of predictor dimensions accounting for the majority of variance of the vocational education groups would be discriminant functions I, II, and III as indicated in Table 1. Fifteen discriminant functions were obtained for the vocational groups; however, the first three were found to account for 74.7 per cent of the total discriminative power of the thirty-nine variables studied. The contribution of the remaining twelve functions toward group classification totaled 25.3 per cent of the discriminating power of the variables. It was decided to use only the first three functions for the validation study due to the minor discriminating contribution to be expected from functions IV through XV. It may be noted that none of the remaining discriminant functions explains more than five per cent of the among-groups variance. Thus, by means of the discriminant function statistic the original 15 by 39 region of test space was reduced to three dimensions which would facilitate the validation study.

TABLE 1

Discriminant Equation Coefficients of the Thirty-nine Variables

Variables *	Discriminant Functions		
	I	II	III
1	0.119	0.055	0.030
2	-0.070	0.145	0.272
3	0.115	0.017	0.063
4	0.094	0.154	-0.098
5	-0.272	-0.010	0.040
6	0.211	0.017	0.206
7	0.083	0.140	0.011
8	0.118	0.026	0.129
9	-0.123	0.098	0.141
10	0.055	-0.055	-0.006
11	-0.020	0.131	0.182
12	-0.032	0.039	0.051
13	0.018	-0.082	0.034
14	0.049	-0.018	0.134
15	0.013	-0.043	0.062
16	-0.140	-0.017	-0.118
17	-0.004	0.029	0.033
18	0.086	0.020	0.051
19	-0.174	0.052	0.144
20	0.114	-0.079	0.096
21	0.067	-0.087	0.142
22	-0.052	0.170	-0.144
23	-0.202	0.089	-0.157
24	-0.308	-0.031	0.169
25	0.047	-0.090	0.103
26	0.152	0.107	-0.012
27	0.043	-0.011	0.267
28	-0.012	-0.068	-0.062
29	-0.095	0.048	-0.020
30	-0.045	-0.020	0.108
31	-0.055	0.018	0.112
32	-0.063	0.088	0.018
33	-0.680	0.705	-0.167
34	-0.198	0.352	0.596
35	-0.140	-0.320	0.297
36	-0.045	-0.190	0.191
37	0.047	0.188	0.143
38	-0.194	0.011	-0.171
39	0.080	0.222	0.035

* The above variables are identified by number on pages 11-12 in the body of the report.

TABLE 2

Discriminating Power of the Discriminant Functions

Discriminant Function	λ	Per Cent of Total λ
I	3.343	52.03
II	.927	14.43
III	.531	8.27
IV	.338	4.96
V	.225	3.79
VI	.196	3.06
VII	.146	2.27
VIII	.139	2.16
IX	.126	1.96
X	.020	1.54
XI	.018	1.34
XII	.012	.98
XIII	.001	.87
XIV	.000	.66
XV	.000	.47

Validation Study

The validation phase of this study involves the prediction of group membership of a random sample of students from known groups of vocational-technical students to determine the usefulness of the computed discriminant equations. There are two generally accepted approaches to the prediction of group membership by resemblance. Both approaches make use of the discriminant scores resulting from substitution of an individual's raw scores into the discriminant equations. In this manner each individual's scores are projected into the reduced discriminant space resulting from Phase I analysis.

One approach to prediction of group membership is the computation of centour scores for all individuals of the validation sample. The centour is an indication of the degree of resemblance a given individual has to a particular group whose centroid and dispersion is known. The centour score estimates the per cent of sample points or discriminant scores that would be farther from the group centroid than the sample point under consideration.

Centour scores, however, are greatly influenced by the sizes of the sample groups used to construct the discriminant equations. Large sized groups result in under assignment and small sized groups tend to be over assigned. Cooley and Lohnes (1962, p. 138) present a routine which results in a probability statement of group membership which controls for the problems of unequal group size. With the use of this routine an individual will have as many probability statements as there are comparison groups. In the present study 16 probability statements were computed for each member of the validation sample.

Ten per cent of the original sample of 585 was randomly identified and set aside for purposes of validating the discriminant equations computed in Phase I. The scores on all variables for each student of the validation sample were then transformed into the reduced discriminant space determined by the Phase I analysis. Thus, each student's three discriminant scores defined a point in three-dimensional space which was then compared with the original 16 probability statements regarding resemblance to a group for all individuals of the validation sample. Classification can then be made in terms of the greatest probability or in terms of the two or three largest probabilities. It seems consistent with present day guidance and counseling purposes to present information to a student regarding which two or three of several groups he most resembles. Table 3 reports the

correspondence of predicted classification by means of the largest, two largest, and three largest probability values and actual vocational course enrollment of the validation sample.

Use of the largest probability value as the criterion for classification would result in a correct prediction of group membership for 28 of the 58 students of the validation sample. The number of correct classifications increases to 41 and 48 for the use of the two and three largest probability values respectively.

Discussion of Results

The results of the study support the hypothesis that secondary school vocational-technical school students enrolled in various trade and industrial curricula have measurably different aptitudes and interests. Further, the discriminant function statistic is capable of revealing the differences between vocational student groups and can reduce the dimensions necessary to explain these differences. This reduction of dimensions allows for more meaningful interpretation of combinations of test scores, thereby increasing the usefulness of the test scores for guidance and counseling purposes.

At the time of educational and vocational planning it would seem likely that many students would welcome information indicating which of several vocational curricular groups they most resemble in terms of aptitude and interest patterns. Classification by means of the discriminant function, while valuable, will not answer all the problems of personnel selection and placement. Many students due to personal motivations will insist on placement in various vocational courses even when group resemblance in terms of discriminant scores or probabilities is contraindicated.

An illustration of how a school counselor might use discriminant equations to provide useful information to a student follows.

Assume that student X has completed the battery of tests and the resulting scores, equations, and probability statements are made concerning his probable group membership. The probabilities calculated for the above set of scores would be presented to the counselor and student in the following form.

TABLE 3

Summary of Actual Classifications Correctly Predicted for Validation Sample by Various Probability Values

	Actual Classification	N	No. Pred. by largest Probability	No. Pred. by two largest Probabilities	No. Pred. by three largest Probabilities
1	Auto Mechanics	4	2	3	4
2	Auto Body and Fender Repair	3	1	1	2
3	Clerical Practice	7	5	6	6
4	C.O.E. Business Education	3	0	1	3
5	Commercial Art	5	3	3	4
6	Commercial Serving	3	1	2	3
7	Cosmetology	1	1	1	1
8	Data Processing	4	0	2	2
9	Electricity	2	2	2	2
10	Electronics	9	8	9	9
11	Graphic Arts	1	1	1	1
12	Key Punch and Machine Operation	2	0	0	0
13	Machine Technology	4	1	3	4
14	Refrigeration-Air Conditioning-Heating	1	0	0	0
15	Secretarial Practice	7	3	6	6
16	Stenography	2	0	1	1
		58	28	41	48
	Per Cent Correctly Classified		48.9	70.7	82.7

1.	Auto Mechanics	p = .23
2.	Auto Body and Fender Repair	p = .00
3.	Clerical Practice	p = .00
4.	C.O.E. Business Education	p = .00
5.	Commercial Art	p = .01
6.	Commercial Serving	p = .00
7.	Cosmetology	p = .00
8.	Data Processing	p = .06
9.	Electricity	p = .06
10.	Electronics	p = .60
11.	Graphic Arts	p = .01
12.	Key Punch and Machine Operation	p = .00
13.	Machine Technology	p = .00
14.	Refrigeration-Air Conditioning-Heating	p = .02
15.	Secretarial Practice	p = .00
16.	Stenography	p = .00
		.99+ per cent

The counselor may choose to interpret the probabilities in terms of their magnitude or state more broadly that the student's pattern of scores on the DVT and MVII are most similar to patterns of boys or girls who have taken electronics, auto mechanics, data processing, and electricity. Availability of discriminant information such as this, coupled with regression equations indicating probable success, would be of value in counseling with youth in a single high school. Much information presently found on cumulative records could be utilized much more efficiently and effectively. The probabilities reported above indicate that there is a certain degree of overlap of the group ellipsoids in multivariate space that cannot be eliminated in the reduced discriminant space. Since there is overlapping of the groups it would seem unfair to inform a student of the single course group he most resembles. Related to the problem of overlapping groups is the fact that schools are faced with the problem of having limited learning stations and job opportunities in most of the trade and industrial occupations. If classification and resultant enrollment were based only upon the maximum probability values some areas would be over assigned while other areas might have insufficient numbers of trainees. The compromise solution to group overlapping appears to be interpretation in terms of the largest two or three probability values.

Since several of the vocational groups appeared to resist classification in the validation portion of the present study it seems appropriate to offer an alternate approach which possibly would enhance correct

classification. A form of multiple phase discriminant analysis might produce a greater "hit" rate.

The initial step in such a paradigm would be to run a discriminant study identical to the one completed for this study. Secondly, the resulting locations of group centroids in reduced discriminant space should be noted and those groups tending to cluster should then be subjected to a separate discriminant analysis. Such a procedure would remove the effect of all excluded groups from the newly computed discriminant space and might lead to greater clarity of group separation. The number of separate discriminant analyses necessary during this second phase would depend upon the number of distinct clusters of group centroids discovered during the first phase analysis. This approach to classification would entail the conversion of an individual's test scores into two or more reduced discriminant space fields which would need little computer time.

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CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The following conclusion seems warranted in view of the finding.

Discriminant equations can be generated which will aid in classification of vocational-technical students according to group resemblance by using aptitude and interest variables. Therefore, the multiple discriminant function statistic could be considered an appropriate technique to aid in the guidance and classification of secondary school vocational-technical students.

Recommendations

In light of the findings of the present study the following recommendations for further research are offered:

(1) A longitudinal discriminant study including all of the identifiable vocational-technical groups in a single secondary school system should be attempted.

(2) Variables of types other than those studied in the present investigation should be subjected to discriminant analysis with vocational-technical students as subjects. Research presently in progress on work values and attitudes might provide potential variables.

(3) A longitudinal study covering as many as ten years needs to be performed. Such a study might incorporate some or all of the above suggestions and perhaps be extended to include analysis of men who have been successful for a number of years in a criterion group occupation. A study initiated with data collection beginning with eighth grade students and analysis performed several years later might provide valuable information for guidance and counseling purposes.

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